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(21) International Application Number: PCT/IL98/00536 (22) International Filing Date: 5 November 1998 (05.11.98) (30) Priority Data: 60/064,300 5 November 1997 (05.11.97) US (71) Applicant (for all designated States except US): OMD DEVICES, L.L.C. [US/US]; 1013 Centre Road, Wilmington, New Castle, DE 19805 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): KIRYUSCHEV, Irina [IL/IL]; Pilihovsky Street 9/9, 69341 Tel Aviv (IL). GLUSHKO, Boris [IL/IL]; Rotshild Street 19/6, 77516 Ashdod (IL). (74) Agent: REINHOLD COHN AND PARTNERS; P.O. Box 4060, 61040 Tel Aviv (IL).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: A METHOD FOR MANUFACTURING AN OPTICAL MEMORY DEVICE <div data-bbox="524 1171 1222 1434" data-label="Image"> </div> (57) Abstract <p>A method for the manufacturing of a three-dimensional information carrier by photolithography is presented. The information carrier has a plurality of data regions (5, 5') spaced apart by intermediate layers (6). The data regions are made of a composition containing a fluorescent material and a photosensitive material, and the intermediate layers are made of a non-fluorescent material.</p>		

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A Method For Manufacturing An Optical Memory Device

FIELD OF THE INVENTION

This invention is in the field of optical memory devices, in particular it relates to a method for manufacturing a 3-dimensional read only memory (ROM) device.

5 BACKGROUND OF THE INVENTION

Compact discs are known optical memory devices, which are widely used particularly with playback and computer devices for retrieving musical and software compositions. Such devices typically comprise only one information-carrying layer and, therefore, suffer from a limited amount of
10 recorded data.

Three-dimensional optical memory devices have been developed typically comprising a plurality of parallel, spaced-apart layers having information carrying regions in which optical properties differ from those of adjacent regions of the layers. One example of such a device is disclosed in
15 U.S. Patent No. 4,090,031. The device comprises a substrate and a plurality of data layers provided on one side of the substrate. Each of the layers comprises data tracks formed of lines of data spots. The data spots are, in turn, formed of either binary coded digital information or frequency or pulse length modulated analog information, which is photographically
20 recorded. The data spots are light reflective. Selection of one data track for playback is accomplished by changing the focus of a reading light beam

from one data layer to another, or by making the data tracks of materials having different optical properties, the reading light being of different wavelengths for different layers. To this end, different color dyes or different photoluminescent materials are used and corresponding color
5 filters are selectively positioned in front of light detectors.

The device described in the above patent is manufactured in the following manner. The data layers are made of photosensitive, reflective material such as photographic film or another suitable recording material including printing ink. The data spots are formed of light reflecting metal
10 material having a reflecting index different from that of the data layers. The data spots are fabricated by either vapor deposition through a mask having an aperture corresponding to the data spots, or etching through a photoresist mask. It is thus evident that such a device suffers from multiple over-reflection when retrieving the information from the layers. Indeed, a
15 reading beam would pass through all the layers, where each layer is reflective. This results in the number of layers being limited to two. For example the known DVD.

SUMMARY OF THE INVENTION

It is the object of the present invention to provide a novel method for
20 manufacturing a three-dimensional read only memory (ROM), having a plurality of spaced-apart data regions made of a composition containing fluorescent material and surrounded by regions made of substantially non-fluorescent material.

Thus the present invention provides a method of making a
25 three-dimensional read only memory (ROM), having at least two information layers consisting of a plurality of spaced-apart data regions capable of generating an output radiation upon excitation by a

predetermined incident exciting radiation, the method comprising a sequence of steps which include

- (a) providing a working layer made of a fluorescent composition containing a photosensitive material and a fluorescent material;
- 5 (b) subjecting said working layer to photolithographic processing to produce said information layer including data regions formed of said fluorescent composition;
- (c) coating the information layer by a non-fluorescent, intermediate layer; and
- 10 (d) repeating the sequence steps (a) to (c) a desired number of times to provide a corresponding additional number of information layers with data regions.

The invention further provides a composition for use in the above method of making a three-dimensional ROM, comprising a fluorescent material
15 dispersed in a photosensitive material. Optionally the said composition may also include a material to be referred to herein a "host material", which is capable of interacting with fluorescent material to provide an efficient conversion of absorbed radiation into fluorescence. Also optionally the said composition may include a solvent.

20 Preferably, the fluorescent materials used according to the present invention absorb within the range of about 500 nm to about 850 nm.

The preferred optional solvent depends on the solubility of the fluorescent materials and photosensitive materials used.

BRIEF DESCRIPTION OF THE DRAWINGS

25 In order to better understand the invention, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the annexed **Figs. 1 to 8** which illustrate sequential steps of the method according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to **Fig. 1**, there is shown a polycarbonate or a glass substrate **1** spin-coated with a layer **2** of a homogeneous composition containing a fluorescent material dissolved in a photoresist. Optionally the composition may contain a host material such as an acrylic laquer, and to its application to the substrate it may have included a solvent.

Figure 2 shows the exposure of the coating layer with a UV light **3** being for example within the range of about 360 nm using a photomask **4** to ensure the desired selective exposure. The exposure doze (incident energy) may for example be within the range of 600 mJ/cm². Optionally, instead of using a photomask, direct imaging may be used.

The exposure is followed by development which removes all exposed parts of layer **2**, and **Fig. 3** shows the post development state which in the substrate **1** is bearing an information layer consisting of a plurality of spaced apart data regions **5**.

Figure 4 shows the positioning of an intermediate, non-fluorescent layer **6** of a photoresist serving for holding together two information layers in spaced relationship as will be explained further below. Optionally the photoresist making up layer **6** is compounded with a host material such as an acrylic lacquer. For application, e.g. by spin-coating, the composition may also comprise a suitable solvent.

Figure 5 shows the illumination of the entire surface of the intermediate layer **6**, e.g. with a UV radiation **7** whereby the intermediate layer is cured, the exposure being for example in the range of about 1500 mJ/cm².

Figure 6 shows the construction of the next working layer and amounts essentially for a repetition of the operation described in figure 1. Thus, a second layer **2'** of a homogeneous composition containing a fluorescent material dissolved in a photoresist is placed on the cured

intermediate layer 6, e. g. by spin-coating. Optionally the composition contains a host material such as an acrylic lacquer, and is dissolved in a solvent for homogeneous coating.

Figures 7 and 8 show operations similar to those of Figs 2 and 3, leading to a three-dimensional ROM disc with two information layers consisting of data regions 5 and 5'.

Thus, as described, a ROM disc according to the invention is composed of distinct fluorescent information layers, with data storage capability, held apart by non-fluorescent intermediate layers not having any data storage capability. The fluorescent information layers are thin, their thickness being for example, within the range from about 0.05 μm to about 5 μm , while the intermediate layers are thicker, for example, within the range from about 10 μm to about 600 μm .

Examples of fluorescent materials suitable for the purpose of the present invention are such that absorb within the range of about 500 nm to about 850 nm. Furthermore, these materials should have a high fluorescent quantum efficiency, their absorption spectrum should include the wavelength of the reading laser light and the fluorescent spectrum be within the sensitive range of the detector. The fluorescent materials may, for example, be selected from the following dyes, the designations being according to Lambdachrome Laserdyes of Labda Physik (Labda Physik GMBH & Co. AM Schlehdron 7, Gottingen, DE) carbazine 122, pyridin 1, nile blue, dqoci, rhodamine 6G, rhodamine 800, dci-2, styryl 6, oxazine 750, dtdci, phenoxazon 9, oxazine 1, IR-140, IR-768, IR-780, IR-786, IR-792 oxazine 170, and mixtures thereof.

The host material, when present, interacts with the fluorescent dye to provide an efficient conversion of absorbed radiation into fluorescence. This is due to spatial separation of the fluorescent components preventing interaction of excited and non-excited centers, spectral lines narrowing,

increasing of excited states effective life time and transition cross-section enhancement. A particular example for such a host material is an acrylic lacquer. It should be specifically noted that the photoresist material can itself serve as a host material. To this end, for example, PMMA β may be
5 used.

The amount of the optionally used solvent determines the thickness of the fluorescent layer remaining after drying. The choice of the solvent depends on the solubility of the dye and the photoresist used as well as on the desired viscosity of the photoresist. By way of example, the solvents
10 used are selected from the group consisting of ketones, aldehydes, C₅-C₁₂ alkanes, alcohols, aromatic solvents and mixtures thereof, a preferred solvent being acetone.

The multilayer fluorescent ROM disc according to the invention is composed of thin fluorescent layers separated by relatively thick
15 non-fluorescent layers. These two types of layers contain the same photoresist but differ in that the thick non-fluorescent layer does not contain any fluorescent material. Thus the refractive index of the two layers is identical whereby the optical distortions are minimized. The photoresist material is preferably of the negative type which facilitates the adhesion of
20 pairs of adjacent layers.

The weight ratios between the components of the fluorescent layer depend on the desired concentration of the fluorescent material. The minimum concentration of fluorescent material is determined by the requirement that the absorption coefficient of the fluorescent material be
25 sufficient to produce a registrable fluorescent signal. The maximum concentration is determined by the need to avoid concentration quenching which reduces fluorescence efficiency, and subject to that limitation it may indeed be desired to maximize the concentration of the fluorescent material in the composition used in making the coating layers 2 and 2' in Figs. 1 and 6.

Typically a fluorescent coating may be produced from the following composition:

- 0.001 – 2 weight % fluorescent dye;
 0 – 55 weight % solvent;
 5 0- 55 weight % host material and
 25 – 55 weight % photosensitive component.

The excitation is provided using suitable laser light beams, e.g. such as are capable of exciting blue/green (i.e. short wavelength fluorescent material) in high-density discs. Where the use of longer wavelengths is
 10 desired, dyes with longer wavelength spectrum should be used.

The invention is further illustrated by the following Example, which is a protocol for the production of a three-dimensional ROM disc.

EXAMPLE

- 15 1. A 120 mm diameter polycarbonate or glass disc is cleaned with an organic solvent.
2. Photoresist ma-N 420 ("Microresist Technology" GmbH) containing dissolved 0.05 weight % of rhodamine 6G is applied to the disc by spinning at 4000 rpm.
- 20 3. Coated disc is prebaked at 90°C for 20 min.
4. Exposure with a UV light at 360 nm using a photomask. Exposure dose (incident energy) is 600 mJ/cm².
5. Development with ma-D532 developer during 1.5 min.
6. Rinsing with deionised water.
- 25 7. Baking at 120°C for 20 min.
8. Applying the intermediate, non-fluorescent layer, using photoresist ma-490 by spin-coating at 1000 rpm.
9. UV illumination of the entire surface, the dose of the exposure being about 1500 mJ/cm².

10. Repeating steps 2 to 9 once or more, to obtain a multi-layer ROM disc.

CLAIMS :

1. A method of making a three-dimensional read only memory (ROM), having at least two information layers consisting of a plurality spaced-apart data regions capable of generating an output radiation upon
5 excitation by coherent or non-coherent incident exciting radiation, the method comprising a sequence of steps which include:
- (a) providing a working layer made of a fluorescent composition containing a photosensitive material and a fluorescent material;
 - (b) subjecting said working layer to photolithographic processing to
10 produce said information layer including data regions formed of said fluorescent composition;
 - (c) coating the information layer by a non-fluorescent, intermediate layer; and
 - (d) repeating the sequence steps (a) to (c) a desired number of times
15 to provide a corresponding additional number of information layers with data regions.
2. The method of making a three-dimensional read only memory (ROM) according to Claim 1, wherein in step (a) working layer is carried
20 by a substrate.
3. The method according to Claim 1 or 2, wherein each fluorescent information layer also includes a host material.
- 25 4. The method according to any one of Claims 1 to 3, wherein the fluorescent material absorbs within the range of from about 500 nm to about 850 nm.

5. The method according to any one of Claims 1 to 4, wherein the photosensitive material is an UV photoresist.
6. The method according to Claim 5, wherein said photoresist is
5 negative photoresist.
7. The method according to any one of Claims 3 to 6, wherein the host material is an acrylic lacquer.
- 10 8. The method according to any one of Claims 1 to 7, wherein the thickness of the fluorescent layer is from about 0.05 μm to about 5 μm , and that of the non-fluorescent intermediate layer is from about 2 μm to about 600 μm .
- 15 9. A fluorescent composition for use in the performance of the method according to any one of Claims 1 to 8, wherein the fluorescent material is a dye being a member selected from the group consisting of carbazine 122, pyridin 1, nile blue, dqoci, rhodamine 6G, rhodamine 800, dci-2, styryl 6, oxazine 750, dtdci, phenoxazon 9, oxazine 1, IR-140,
20 IR-768, IR-780, IR-786, IR-792 and oxazine 170 and compositions thereof.
10. The fluorescent composition according to Claim 9, comprising a fluorescent material dispersed in a photosensitive material.
- 25 11. The method according to any one of Claims 1 to 8, wherein the non-fluorescent, intermediate layer containing the photosensitive material and method further comprising step of illuminating said intermediate non-fluorescent layer to provide adhesion between the information layer and said intermediate layer.

12. The fluorescent composition according to Claim 10, also comprising a member of the group consisting of host materials and solvents.

13. The fluorescent composition according to Claim 12, wherein the
5 solvent is a member selected from the group consisting of ketones, aldehydes, C₅-C₁₂ alkanes, alcohols, aromatic solvents and mixtures thereof.

14. The fluorescent composition according to Claim 12, wherein the solvent is acetone.

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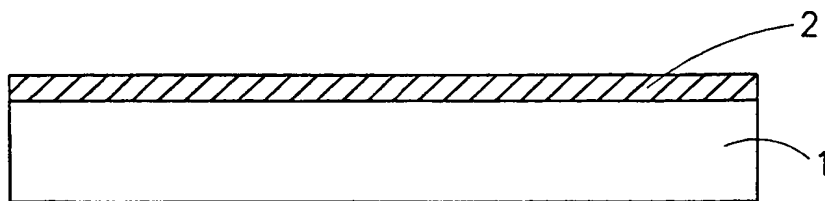


FIG. 1

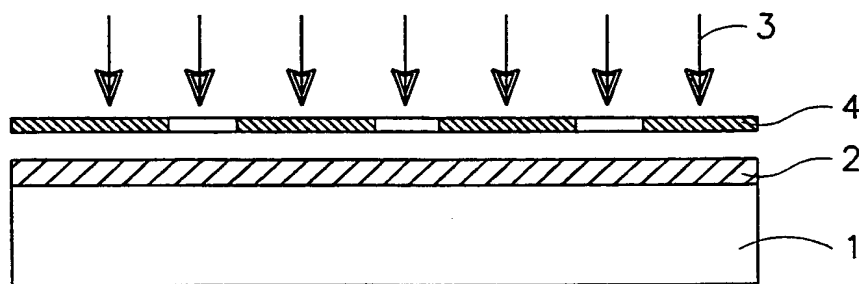


FIG. 2

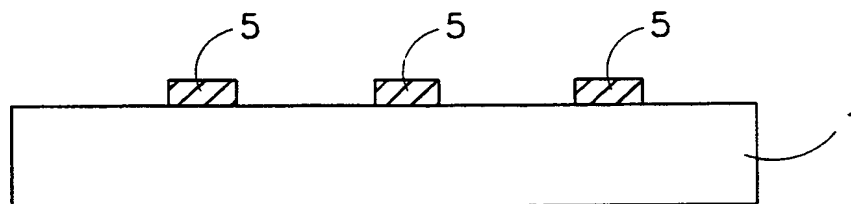


FIG. 3

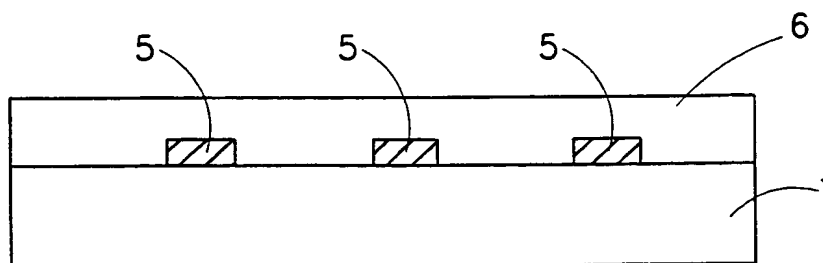


FIG. 4

2/2

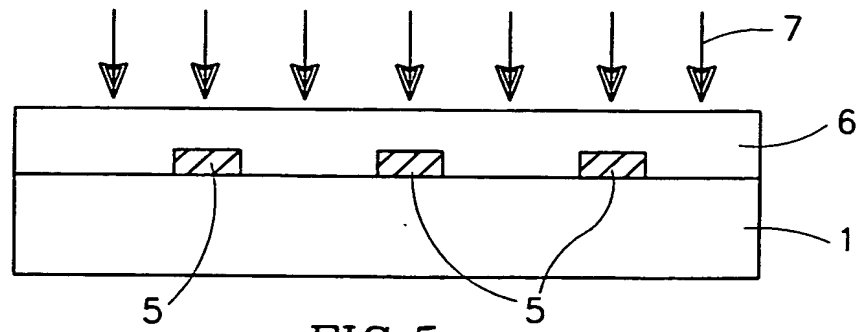


FIG. 5

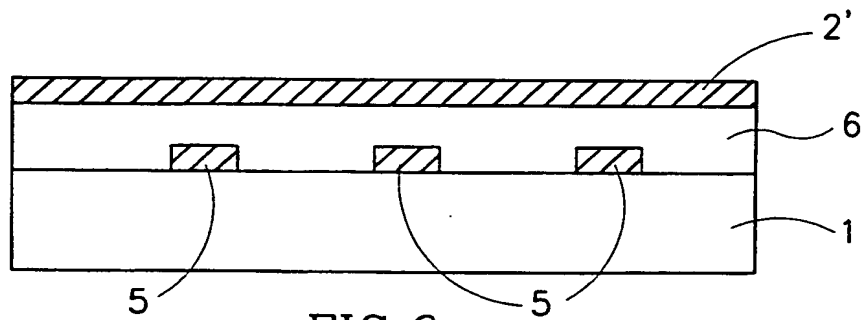


FIG. 6

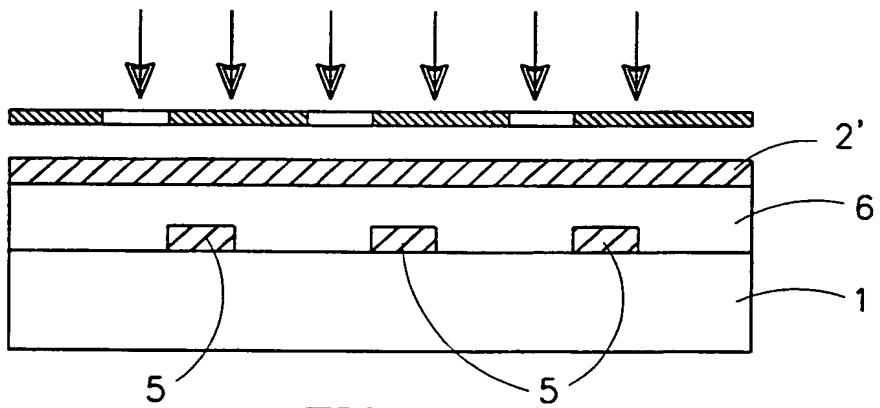


FIG. 7

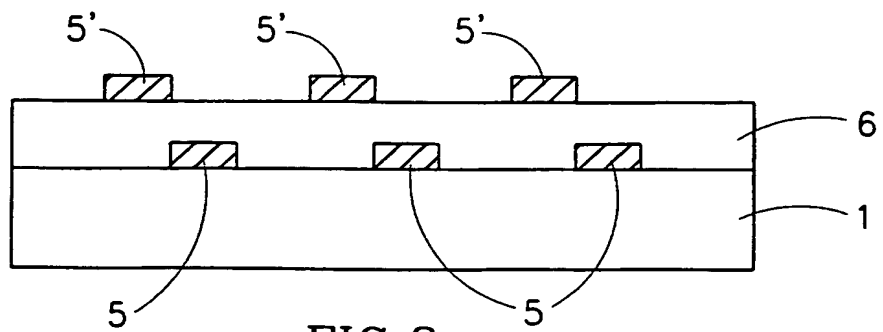


FIG. 8

INTERNATIONAL SEARCH REPORT

In International Application No

PCT/IL 98/00536

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B7/26 G11B7/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 460 347 A (PIONEER ELECTRONIC CORP) 11 December 1991 see the whole document ---	1,2,5-7
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 002, 29 February 1996 & JP 07 282466 A (FURUKAWA ELECTRIC CO LTD:THE), 27 October 1995 see abstract -----	1,2,8



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

25 February 1999

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04/03/1999

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0460347 A	11-12-1991	JP 4038732 A	07-02-1992
		DE 69119476 D	20-06-1996
		DE 69119476 T	19-09-1996
		US 5182669 A	26-01-1993
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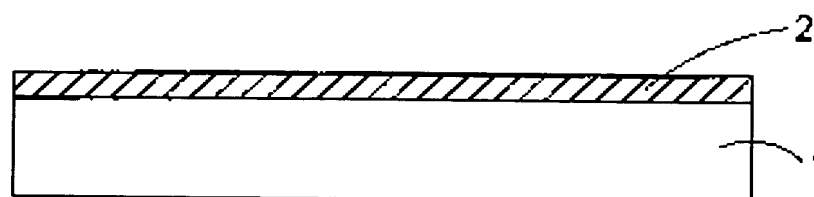


FIG. 1

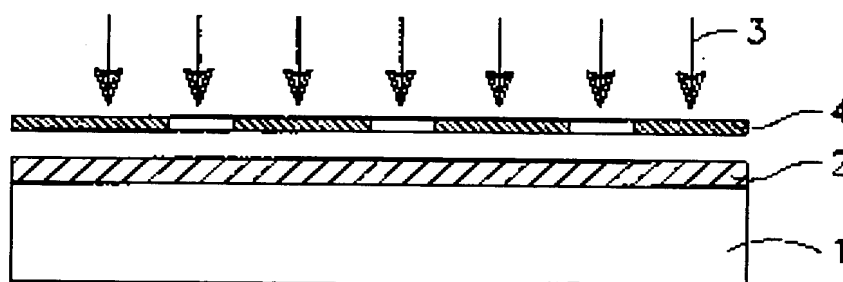


FIG. 2

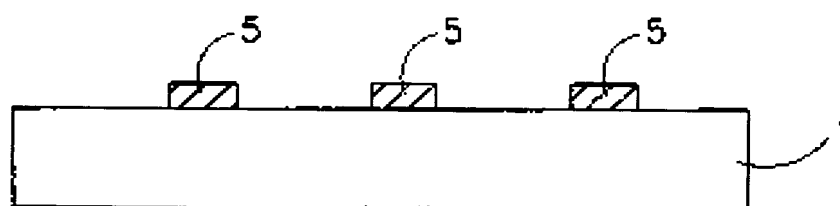


FIG. 3

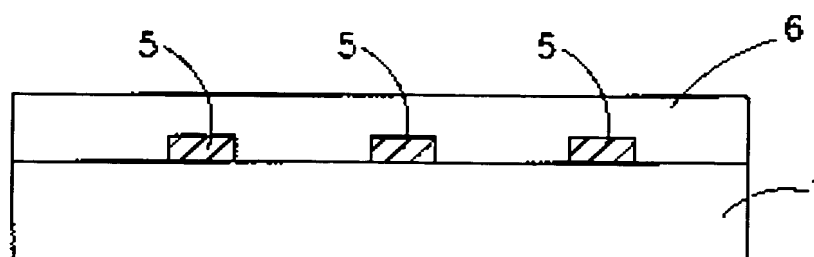


FIG. 4

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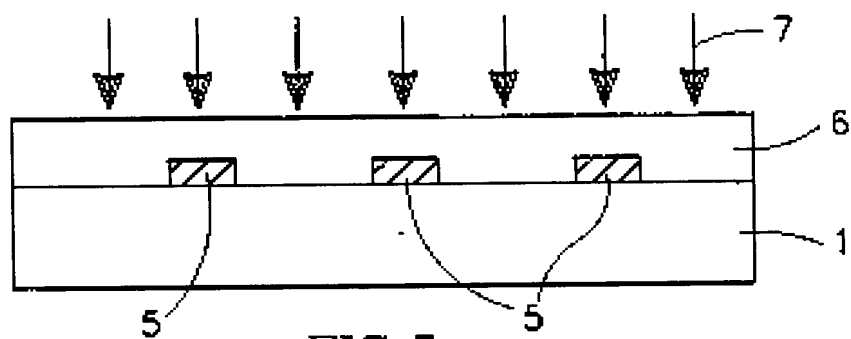


FIG. 5

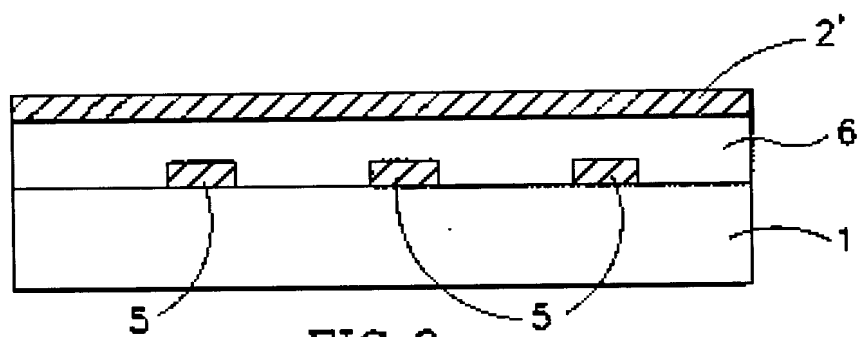


FIG. 6

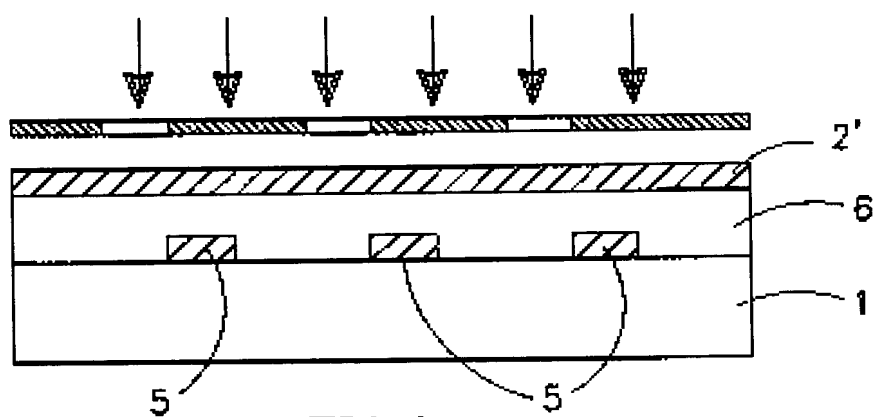


FIG. 7

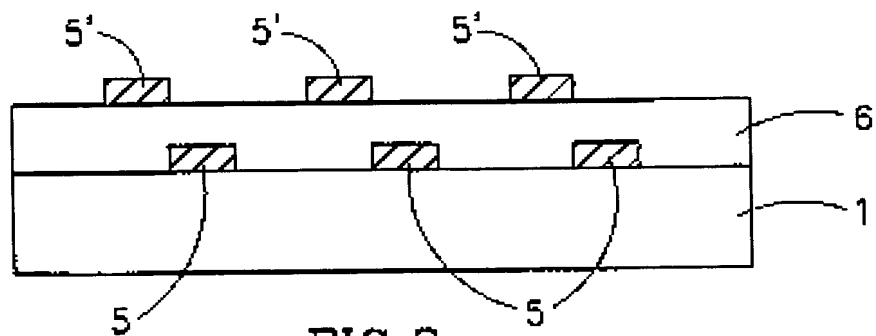


FIG. 8